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Project: Image Enhancement for the Visible-Light Beam Size Monitor at CESRTA

A visible-light beam size monitor has been built and commissioned to measure transverse beam profiles at CESR-TA. A fast gated camera is good for bunch-by-bunch beam profile measurements. However, it has larger pixel size (13.5 microns) than a conventional CCD camera (4.4 microns). In order to use it, we need to magnify the beam image. We created a test-bunch setup for interferometer method using a filament source emulating the beam source. After applying either a single lens or microscopic lens, we found that both magnification schemes work fine but better with a single lens.

In the beginning of our project, we collected data from the storage ring. After third week, we aligned optical elements outside the tunnel. First a laser was placed at approximately 2.00 m from the first lens as the source point. In this order, the iris, the slits, the focusing lens and a finally mirrors were assembled in the optical box. On the optical table, light coming from a filament source passed through a second lens with 0.0756m focal length, a polarizer, and 500nm bandpass filter. The light reached its final path going through filter to reach location of the cameras, where CCD camera or fast-gated camera is placed. Once we tried two methods to magnify image, using a single lens or microscopic lens, it turned out that visibility is much better with a single lens. The reason, for getting better visibility with one after another, was that the single lens has larger aperture and let most of light pass through while microscopic lens only passed less than 50% of light. We measured a beam profile using interferometer method. If the beam shape was a Gaussian profile, its width sigma x is related to visibility. By obtaining and fitting interference pattern to visibility we can calculated the beam size. If the beam had a uniform distribution, we used another formula to find the half width, which also required to find spacial coherence (visibility) by fitting the interference pattern. In the last, we checked the best interference pattern using gated camera. We found the image wasn’t magnified large enough.

In conclusion, the goal of this project was reached to create a test-bench setup, find different magnification schemes, and check the image quality with gated camera. Results from our images show that magnification using a single lens, using Plano-convex lens to cancel aberration, have a better visibility and better image quality. In order to use gated camera, magnification larger than 3.0 should be used.